The Design and Usability Testing of DACADE – A Tool Supporting Systematic Data Collection and Analysis for Design Students

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Abstract. Norman claims that designers are bereft of statistical knowledge to perform effectively [10], stating that designers must understand technology, business and psychology to support design decisions. For designers to acquire the necessary statistical skills, design curricula should incorporate statistical courses teaching systematic data collection and data analysis. This paper presents the development and formative usability tests of the prototypes of a software tool called DACADE intended to support design students collecting and analyzing data systematically early in the design phase. It uses a 2D map and a Napping® technique to support effective and efficient communication between designers and target audiences in the design decision process by providing visual data and descriptive statistics without needing statistical knowledge.
Keywords: Software Engineering **(**Usability Testing), Human Factors in Software Design (User Interfaces), user-centered design, human-centered design

1 Introduction

With the spread of the Internet, large-scale data collection, analysis, and product/ service testing are feasible and cost-effective. Specialist companies provide statistical packages, such as SPSS to analyse test results as well as offering data entry services and even data analysis. This complements the trend of data mining in both the retail and the social media advertising domains. Inevitably, however, the analyses tend to be biased towards quantitative rather than qualitative outcomes; statistical procedures employed vary from simple Cluster Analysis to Multidimensional Scaling and Multi-

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[1] Please note that the LNCS Editorial assumes that all authors have used the western naming convention, with given names preceding surnames. This determines the structure of the names in the running heads and the author index.

ple Regression, even Structural Equation Modelling. Design company clients will increasingly receive market research reports incorporating such analyses.

In our study, we first interviewed 20 design students and 10 design lecturers at one University, followed by a survey of 51 universities with design courses in Australia, North America, Europe, United Kingdom, and Asia. Results revealed that none of the curricula included statistics, thus supporting Norman's claim that design students do not understand statistical concepts. It is therefore legitimate to question future designers' ability to understand statistical information as well as their ability to engage actively and meaningfully in this emerging world of statistical sophistication. Norman contends that they cannot [10]. The **Da**ta **C**ollection and **A**nalysis for **De**signers (DACADE) software tool described here aims to help future designers collect and analyze product-related data from prospective consumers.

1.1 Existing visual statistical tools

Research shows that designers prefer visual information [6]. Following Kälviäinen et al., [8], this study thus focuses on tools allowing visual data collection and analysis. Several visual research tools that automate data collection and analysis are available in the literature, including Computer Aided Kansei Engineering (CAKE) with XML [2], the Web-based 2 Dimensional (2D) analytical tool [9] allowing respondents to position images of products on a 2D map using Semantic Differentials (SD), 3), and others. Tools based on SDs scales require designers to pre-assign sets of bipolar adjectives to product images (e.g. Bad – Good, Ugly – Pretty). Kälviäinen et al., [8] proposed that product images with pre-assigned sets of bipolar adjectives could constrain the respondents' possible suggestions and that respondents should be free to evaluate products as they see fit [8]. Some of the available tools assume that designers know statistics: none of these have been tailor-made for future designers.

1.2 Napping® and 2D map

DACADE includes two techniques for collecting and analyzing opinion data. One allows evaluators to position product images on a blank screen in any way they like. Products positioned close to others are perceived to be similar; those positioned far apart are seen to be different. Once all images have been placed, evaluators enter adjectives to represent the products/groupings meaningfully. Based on these evaluator-selected terms, designers can then select suitable bipolar adjective pairs for further study. This technique is called projective mapping or Napping®. It is used widely in sensory analyses in the food industry [11]. Based on the sets of original adjective-pairs, other respondents' product perceptions can be tested in later design stages.

Involving a 2D map that enables the direct reading of consumers' perception, the second technique relies on designer-selected adjective-sets from which the designer generates a perceptual map of consumer perception. Perceptual maps are popular in marketing for studying the perception of products ranging from consumer products (e.g. toothpaste, cars) to activities (vacation spots, movies) [12]. DACADE uses perceptual maps because they are easy to interpret, and they provide visual output as designers prefer. Marketing researchers and practitioners tend to rely on statistical software packages such as SPSS to run highly advanced statistical analyses that may be too complex for statistically naïve design students. Instead, DACADE uses non-parametric Guttman-Lingoes Series MDS [4, 5] that rely on visual and spatial information for generating perceptual maps.

2 Initial design and first formative DACADE usability test

DACADE was designed using User-Centred Design (UCD) [13] and the ISO-9241/11 [7] definition of usability, i.e. effectiveness, efficiency, and user satisfaction. Five graduate design students evaluated the initial evaluation low-fidelity paper prototype in individual sessions, audio recorded with permission. A separate prototype was produced for each of four tasks, namely (1) designing a new study, (2) editing an existing study, (3) collecting data (i.e. running the study) using both abovementioned techniques, and (4) conducting simple descriptive statistical analyses. The analysis component calculates the median, mode, and mean of the research data as well as providing a visual output of the distribution of objects tested. Written task instructions and relevant task scenarios were given; answers were written on a blank sheet of paper. On each screen, participants placed a pen on the object they wished to select. Task requirements were generated separately for each task and given to participants one at a time. All tasks were completed in the same order (1-4). The stimuli comprised some 10 pictures of cars borrowed from Effendi [3]. Upon completing a task, participants filled in the System Usability Scale (SUS) [1] to assess user satisfaction. Notes were taken throughout the sessions; audio records were transcribed verbatim.

Some 31 comments were made of which 15 concerned usability of the remaining 16 issues; six clearly indicated that the students had not grasped the underlying statistical concepts concerning the central tendencies of a distribution. For example, one participant said: "*I think I like them, but I think it assumes that I already know what does this means or even what frequency or mean is, I want to do that, but maybe I don't even know what that is. It seems like a basic thing someone should know in statistics*". This feedback such as this revealed the need for a tutorial component for designers to understand simple quantitative data analysis. Additional comments concerned slight confusions. For example, the 'Edit' button was changed to 'Add Image'. One participant did not recognize check boxes drawn on one screen, possibly because of the rough drawing. Six suggestions were made, for example: "*I don't see why I have to press Cool and click Insert. Wasting my time. Should be done automatically, just click Cool*". All of these were incorporated into the second prototype.

3 Design and test of the DACADE tutorial

The tutorial designed next, covers the four DACADE components as well as a basic explanation and illustration of descriptive statistics. The tutorial was first tested with four new participants who did not complete the tasks in the formal tool. In order to illustrate the calculation of the mean, mode, and median, a picture of bananas varying in size was produced as shown in Fig. 1. Surprisingly, the students perceived this as having sexual connotations, which was both inappropriate and embarrassing for the researcher. The image was therefore changed to a set of books as shown in Fig. 2. This appeared to convey the intended meaning. Several exercises were included in the tutorial. One required participants to calculate the mean, mode, and median of a set of numbers differing from those in the illustration, as shown in Fig. 3. Unfortunately, the median had inadvertently been placed in the center of the distribution in Fig. 2. Rather than calculating the median of the unsorted data set as required, one participant simply counted the number of books from each end of the distribution, selecting the central number ("13") without considering the values of the numbers in the data set. Evidently, the concept was still not conveyed clearly enough. The image was therefore changed again to avoid the median being in the central position.

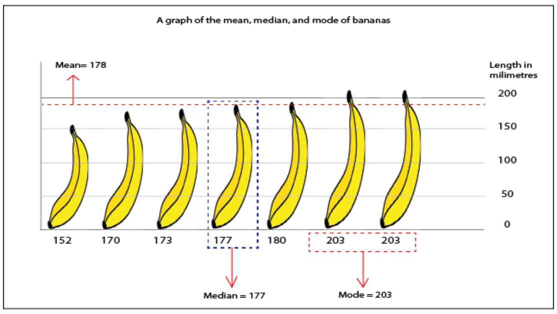

Fig. 1. The original illustration of the mean, median and mode

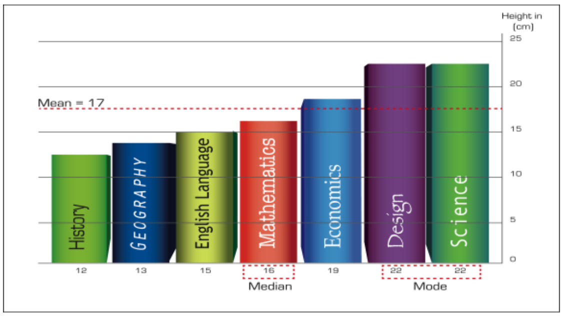

Fig. 2. The replacement illustration of the mean, median and mode

Find the mean, median and mode, for the following list of values:
13. 18. 13. 14. 13. 16. 14. 21. 13

Fig. 3. The data set shown in the tutorial exercise

4 Second formative usability (and comprehension) test

As there were no additional usability issues or apparent comprehensibility issues, the next test, involving the revised tutorial and the revised DACADE tool, included a new sample of six participants together with the original instructions and tasks. Participants worked through the tutorial and exercises first. They were then given the cover story and the task instructions and asked to work with the tool. The results showed a distinct improvement to DACADE: only five (9.43%) of the 53 issues were usability-related. However, some 19 (35.85%) issues concerned a lack of comprehension. Another 17 (32.08%) were suggestions, eight (15.09%) were participants' uncategorized comments, and four (7.55%) were the researcher's observations.

Among the comprehension issues, one showed that participants had difficulties understanding the purpose and meaning of the 2D map, shown in Fig. 4. In both the tutorial and the tool, references were made to a fictitious study of water bottles. In one tutorial exercise, participants were asked to identify the most interesting and modern water bottle, the most traditional and boring bottle, and so forth. We explained that, for both sets of adjectives (boring-interesting and traditional-modern), 'more is better', with the most negative term placed on the bottom and to the left, with the most positive term placed at the top and to the right.

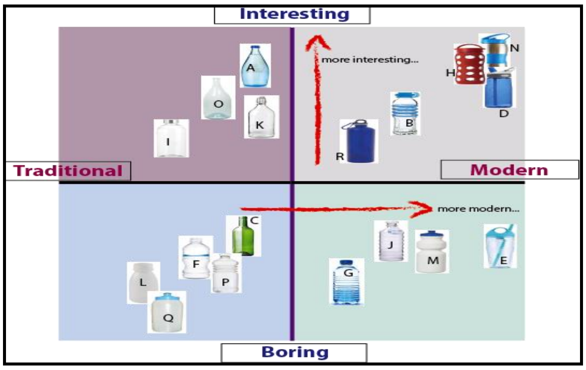

Fig. 4: A perceptual map showing the placement of eighteen water bottles

We also explained the meaning of clusters (mode), and so on. Still, when asked to interpret the contents of the map in Fig. 4, said to represent the placement of bottles by another participant, one participant, noting certain similarities between bottles, said: "*Its like more of a sample, I would say they should be in the same place, because they are all the same. Similar bottles should be in the same place, like now they are kind of everywhere. They are all the same*". Similarly, when asked to identify the best bottle, one participant said: "*The answer is R, because it is made of metal, so you can bring it on to outdoors or, go [*on an*] expedition, that's my judgment*". Another participant said: "*The best bottle, it depends on environmentally, or the needs, like a flask or something, for me I'll just go for B*". Another participant, who was unsure of the position on a 2D map, asked, "*Does it matter if it is located further up on the quadrant*?" This participant further commented that the perceptual map, *"…itself looks* *very statistical and technical; you need to make it more fun and interesting. I want to be able to enjoy the graphics. It really depends on how you design this later*” At this stage, we are at a loss as to how to convey the meaning of visually presented data more clearly, but this problem must be solved before redesigning the prototype.

Other misunderstandings were due the prototype being presented on paper. For example, as shown in Figure 5, two participants did not recognize that the meaning of a greyed-out button was the same as on a computer.

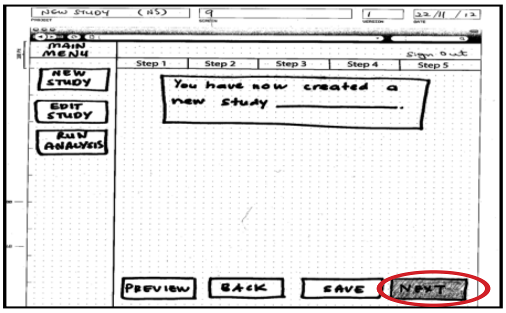

Fig. 5: A screen with a greyed-out button

Participants were also confused about adding a new map on a paper screen. That function enables designers to add one or more 2D maps to be tested in their study. However, instead of adding a new map, they just changed the adjectives on the existing map. This will hopefully be overcome once we use high-fidelity prototypes.

One participant wanted a definition of the term ‘adjectives’, “*The word adjective might confuse people. I think 90% of people don’t read instruction manuals; there should be some rough instructions. You can add a link or a question mark symbol so that people can click on them to get some hints. Or roll over to get some tips”.* Tooltips will be provided in the implemented version of DACADE. Another suggestion was to present the tool online, to enable the designers to involve more people in their studies. While large samples make sense, one of the aims of DACADE is to educate design students and help them to interact and communicate with prospective consumers face-to-face. In future, DACADE might be extended once designers begin to use it, but for the moment, this suggestion will not be considered. Failing to understand the concepts of groups of participants and total number of participants, some participants suggested that DACADE should allow an unlimited number of participants, which it does, but also that the number of participants in a group should not be constrained. That is, they wanted the concept of participant-groups removed. This is infeasible because the tool is specifically designed to guide them in conducting systematic research. This includes the ability to compare between-group responses, e.g. seniors versus teenagers, or allowing the same number of males and females.

Participants made several good suggestions, for example, adding clear instruction to consumers to position images on a 2D map or a blank screen because consumers will not be reading the tutorial. For the task of creating a new study, it is clear that additional instructions are needed. However, in the light of the comment that *“...90%*

of people don't read instructions", it is difficult to balance the amount of instructional text and diagrams. One possible solution is to animate the tutorial, thereby changing it to a 'show and tell' show, with voice-overs and animated diagrams only. This may be done later. Note, however, that if students are unfamiliar with terms such as 'adjectives', even a voice-over will not necessarily help them. Another suggestion was to enable simultaneous display of all images to be placed on the map instead of presenting them one by one. This will be done to give consumers a general idea of the entire range of product images to be positioned from the start of the task. In previous research [2,9], images were presented one at a time or in pairs.

One important observation was that participants looked bored while working through the tutorial. They complained that it was too long and had too much text, again suggesting that animation may be best for creating a playful, yet useful and comprehensive tutorial while retaining its brevity. Finally, it was clear that some participants failed to read the tasks thoroughly; they needed several reminders to refer to the task instructions on how to proceed.

5 Second formative usability (and comprehension) test

Usability goals were set for both tests in terms of the number of questions, hints, and errors allowed during the usability tests. Table 1 shows the distributions of these for each of the four tasks and the results for both usability tests of the DACADE tool.

Table 1: The usability goals set for both tests according to tasks

Tasks	Test1				Test2			
	NS	ES	CD	RA	NS	ES	CD	RA
Questions	3	2	1	3	2	0	0	2
Hints	2	1	1	1	1	1	0	1
Errors	2	2	1	2	0	0	0	0
Results	P	P	P	F	P	P	P	P

**Note: NS=New Study, ES=Edit Study, CD=Collecting Data, RA=Running analyses, P=Pass, F=Fail*

The between-task variation in these numbers in Test 1 was based on our best guess of the difficulty associated with each task. Clearly, the task of 'Running one or more analyses' or RA was most difficult, as it was the only task that failed in Test 1. In Test 2, the goals were based on the outcome of Test 1. Note that the goals were more stringent in Test 2 than in Test 1 because we assumed that the tutorial added in Test 2 would enable participants to understand the descriptive statistics and interpret the perceptual maps. The fact that all four tasks passed in Test 2 could lead one to misinterpret the tool's apparent effectiveness. In cases in which user comprehension may be as important as, if not more important than, usability, comprehension should be added in the task protocol as a separate variable in the performance assessment.

6 Conclusion and Next Steps

This paper described the design of a visual statistical technique to help future designers understand consumers' product perceptions. We showed that it was relatively easy to identify and eliminate usability problems, but that finding effective ways to convey even simple statistical knowledge is fraught with unforeseen difficulties.

The issues from the second usability test are now being addressed, but rather than producing a slightly another prototype, DACADE will be implemented, and professional designers will be consulted on its look and feel. It is anticipated that the results of a user acceptance study will be available by the time INTERACT'2013 takes place.

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